



Armed Forces College of Medicine AFCM





Bone 2

(Bone matrix and Types of bone)

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INTENDED LEARNING OBJECTIVES (ILO)



By the end of this lecture the student will be able to:

- 1. Describe** the microscopic structure of bone matrix.
- 2. Compare** between mature and immature bone
- 3. Describe** the microscopic structure, functions and sites of the compact bone and cancellous bone.
- 4. Mention** the types of ossification of bone.
- 5. Deduce** the different ways of bone growth in length and width
- 6. Interpret** the defective microscopic bone structure in various diseases



Key Points



- Microscopic structure of bone matrix.
- Microscopic structure of periosteum & endosteum.
- Differentiate between immature & mature bone.
- Histological structure of compact & cancellous bone.
- Differentiate between intramembranous & intracartilaginous ossification.
- Bone growth, remodeling & medical application.

Bone Intercellular Substance (Matrix)



➤ **25% water**

➤ **75% hard**

substances:

1. Organic

**components 35 %
(osteoid tissue)**

2. Inorganic

components 65 %





Hard substances

**Organic
(35% dry wt)**

**1- Type I collagen fibers
(90 %) → acidophilic
matrix**

2- Macromolecules as:

- **Sulfated & non-sulphated glycosaminoglycans**
- **Proteoglycans**
- **Glycoproteins
(Osteonectin & Osteocalcin**

**Inorganic
(65% dry wt)**

Calcium & phosphate
In the form of **Calcium hydroxy apatite crystals**
(Na, K, Mg, HCO₃ in small amount)





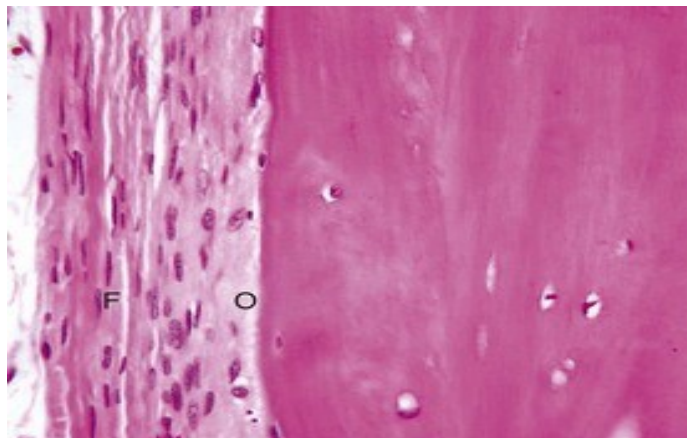
- The matrix is deposited in the form of bone lamellae (**calcified osteoid tissue**).
- It is **acidophilic** with many lacunae inside which the **osteocytes** present in between these lamellae and **their processes** inside canaliculi.
- It is **vascular**.

Give reason or Explain:

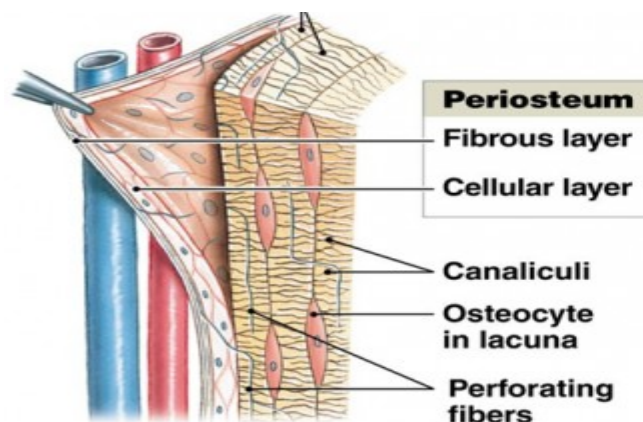
Bone is deformed in patients suffering from scurvy "vitamin C deficiency"

- Due to defective formation of collagen as collagen I is the main constituent (90%) of bone matrix





https://veteriankey.com/wp-content/uploads/2016/09/B9780323075336000164_f016-016-9780323075336.jpg



a The periosteum contains outer (fibrous) and inner (cellular) layers. Collagen fibers of the periosteum are continuous with those of the bone, adjacent joint capsules, and attached tendons and ligaments.

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<http://clickmypicture.com/wp-content/uploads/2019/04/periosteum-the-periosteum-and-endosteum-anatomy-physiology-anatomy-templates-728x570.png>

New Five Year Program

Periosteum

**Outer
fibrous** layer

**Inner
osteogenic
(cellular)
layer**

**Dense
irregular C.T.**
Collagen I
 Fibroblasts
 Fibrocytes &
blood vessels

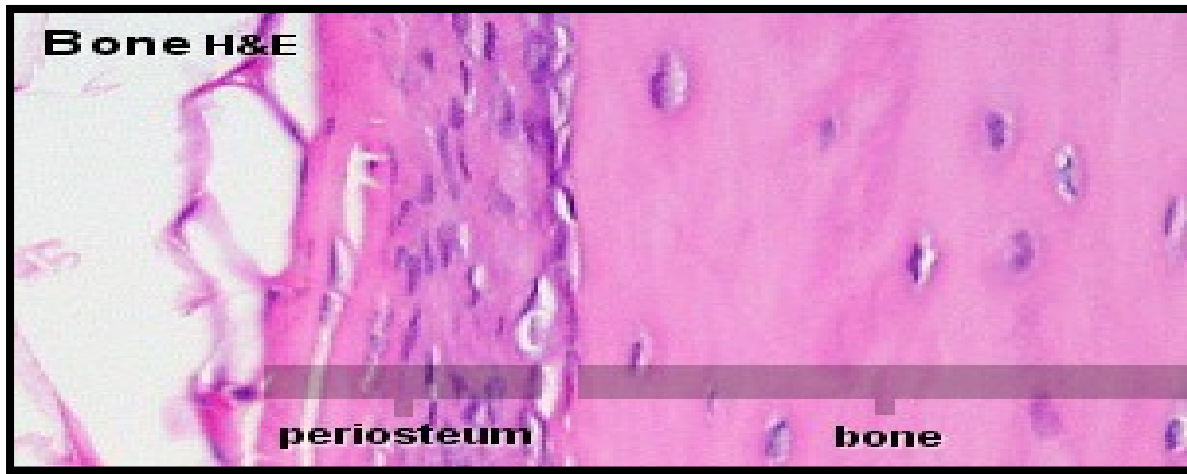
Loose C.T.
Blood vessels
 Osteogenic cells
 Osteoblasts



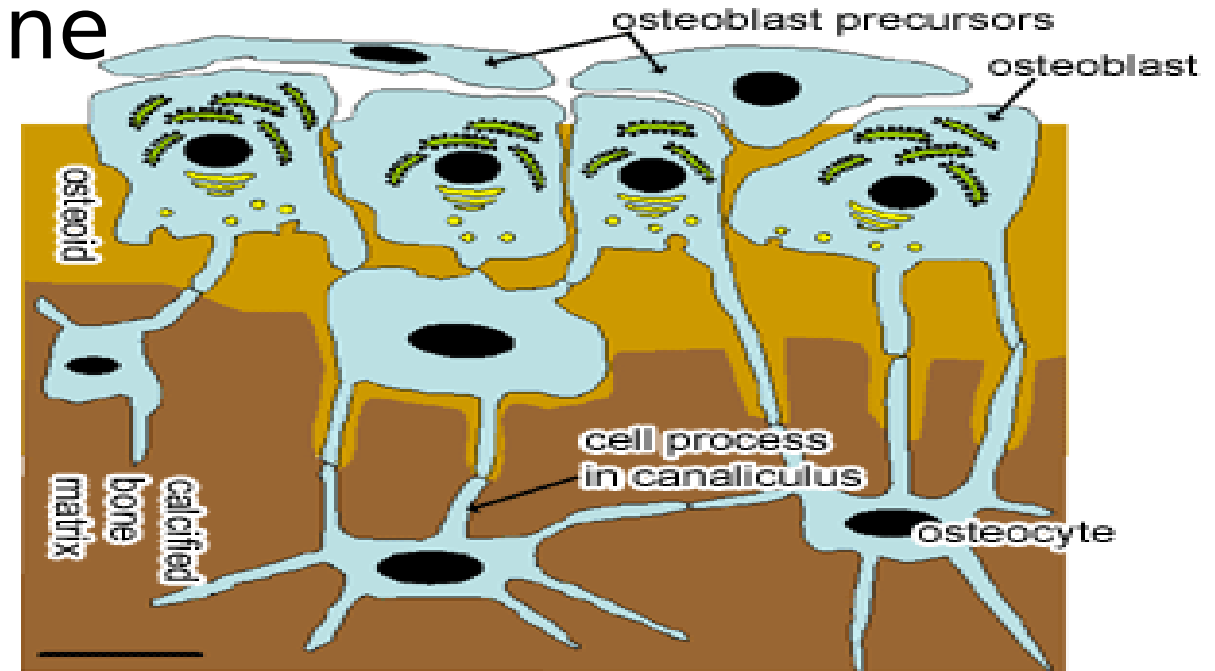
Function of the Periosteum:



1. Nutrition of bone.
2. Attachment of muscles & tendons
3. Appositional growth of bone
4. Repair of bone fractures



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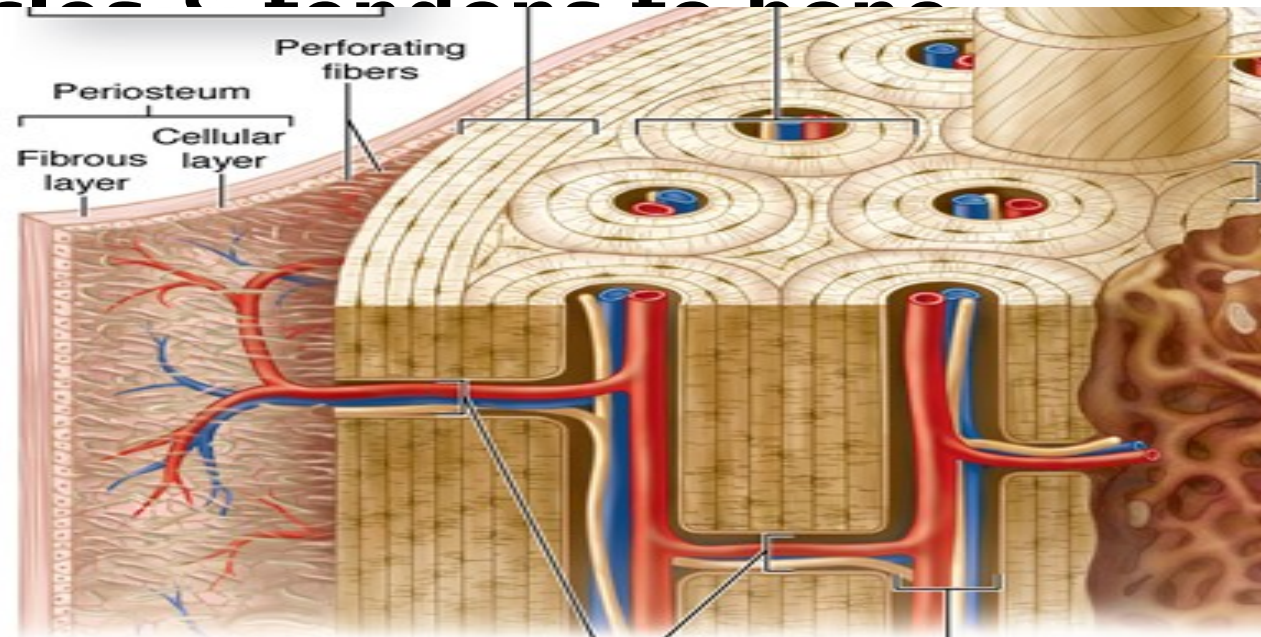
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➤ The perforating fibers of Sharpey's:

- Are periosteal **calcified collagen fibers** anchoring and fix the periosteum to bone matrix.
- They extend from periosteum → penetrating bone thickness.
- They fix muscles & tendons to bone.



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Endosteum

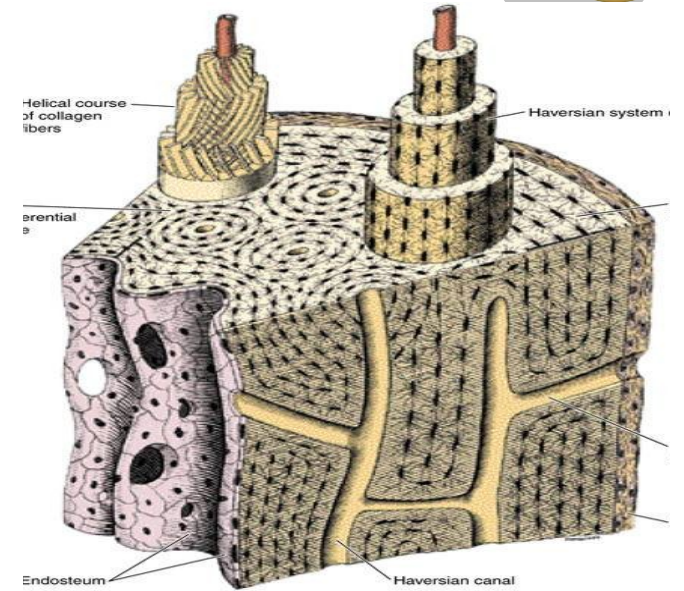
Is **thinner** than periosteum & covering all **internal** cavities of bone

Small amount of vascular C.T.

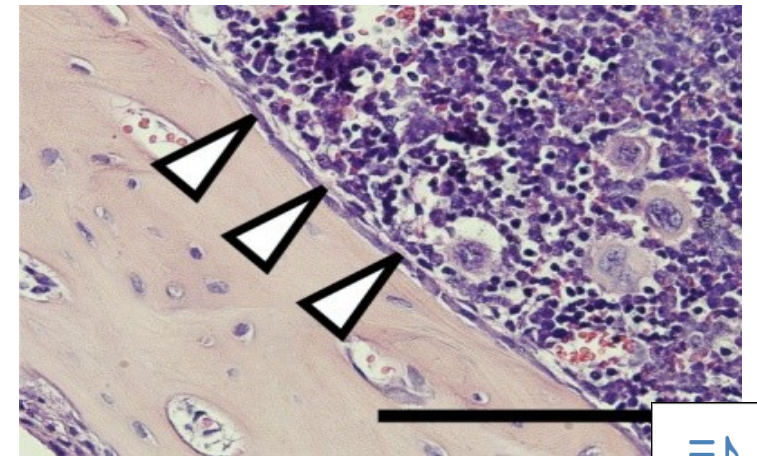
osteogenic cells,
osteoblasts &
osteoclasts

Function of the Endosteum:

- . Nutrition of bone.
- . Appositional growth of bone.
- . Repair of bone fractures & remodeling.



<http://intranet.tdmu.edu.ua/>



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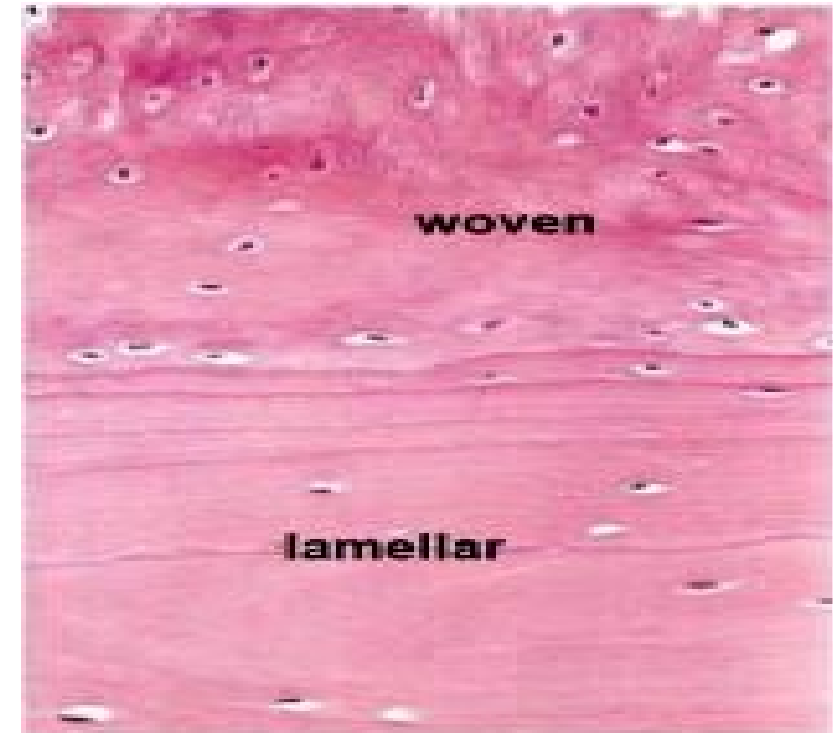


Types of Bone



1- According to maturity

1. **Immature bone** (primary or non lamellar or woven bone)
2. **Mature bone** (secondary or lamellar bone)



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Woven/Immature/Non-Lamellar Bone



- It is the **first bone to appear** (in fetal development and bone fracture repair).
 - It is **temporary tissue** which is soon replaced by mature bone.
- It is characterized by:**

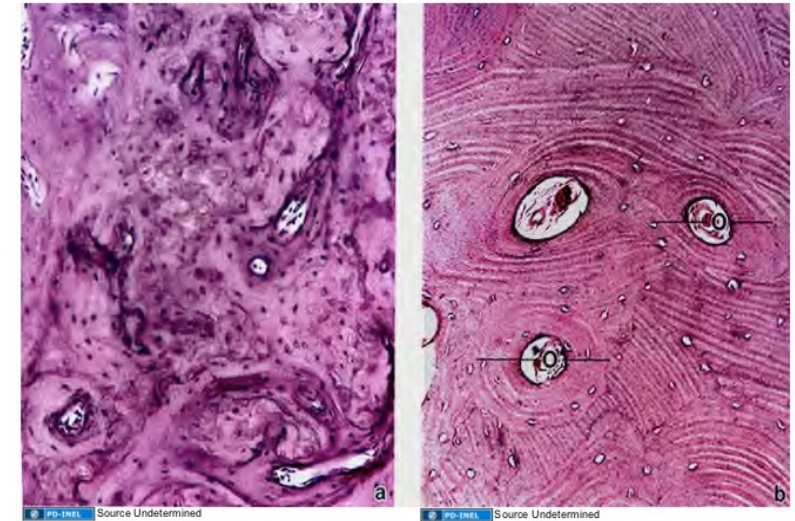
- **Higher contents** of water, cells and organic amorphous component
- **Decreased mineral** content.
- **Bundles of collagenous fibres** run in different directions.
- Woven bone is **flexible, easily deformed and weaker** than mature bone.

In adults it is seen in:

- **Tooth sockets**
- **Near suture lines in the skull**
- **Insertion sites of tendons**
- **Areas of bone repair**

Immature and Mature Bone

(nonlamellar, bundle, or woven bone)



<https://image.slidesharecdn.com/101308-histo-bonegrowthho-111024180049-phpapp02/95/101308-histology-bone-formation-and-remodeling-27-728.jpg?cb=1319719485>



Lecture Quiz



-The outer covering of bone is called:

- a. Perimysium
- ☒ b. Periosteum
- c. Perichondrium
- d. Endosteum



Lecture Quiz



-The following are characteristics of immature bone EXCEPT:

- A. Large number of osteocytes
- B. Low mineral contents
- ☒ C. Minute contents of proteoglycans
- D. Irregular arrangement of collagen fibers

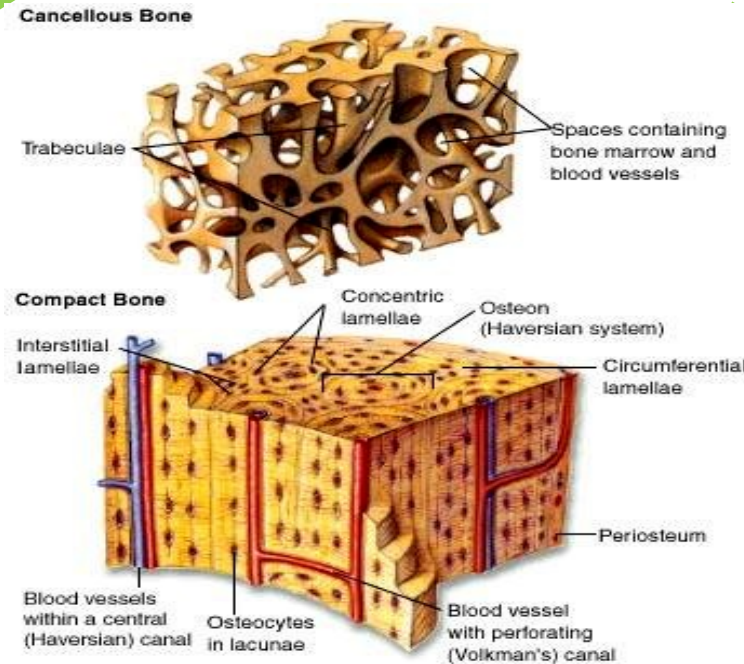


Types of Bone



2- According to the regularity of bone lamellae, bone can be classified into:

Compact bone



Cancellous or spongy bone

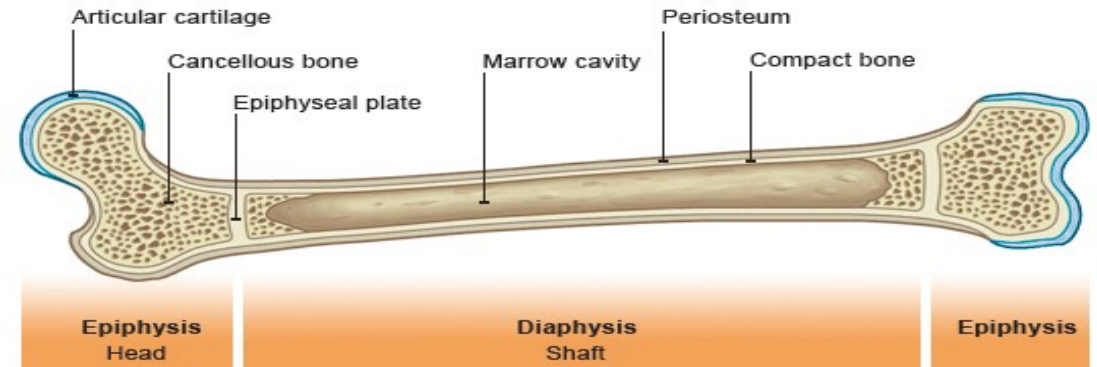
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Musculo-skeletal Module





1. Compact (ivory or regular)

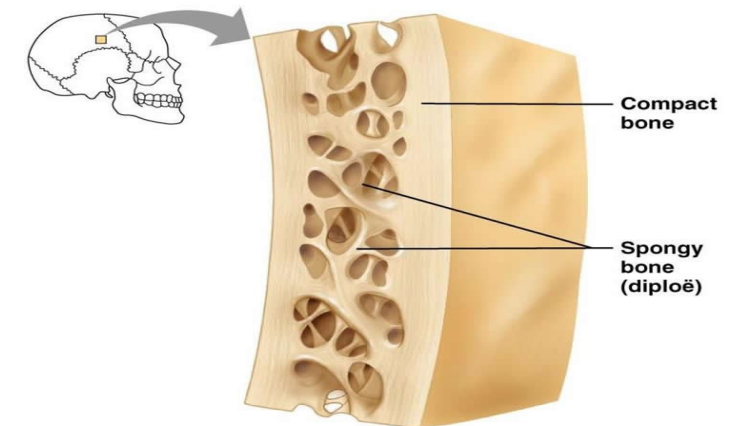
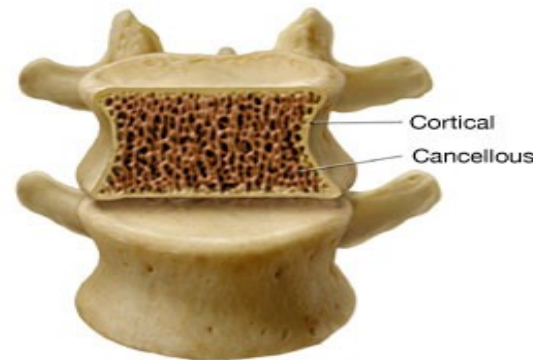
- a. **Shafts** of long bones (diaphysis).
- b. **Outer and inner tables** of flat bone.
- c. **Outer covering** of small or irregular bones.



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2. Spongy (cancellous or irregular)

- a. **Epiphysis** of long bones.
- b. **Body** of vertebrae.
- c. **Middle diploe** of flat bone
- d. **Shaft** of the ribs.



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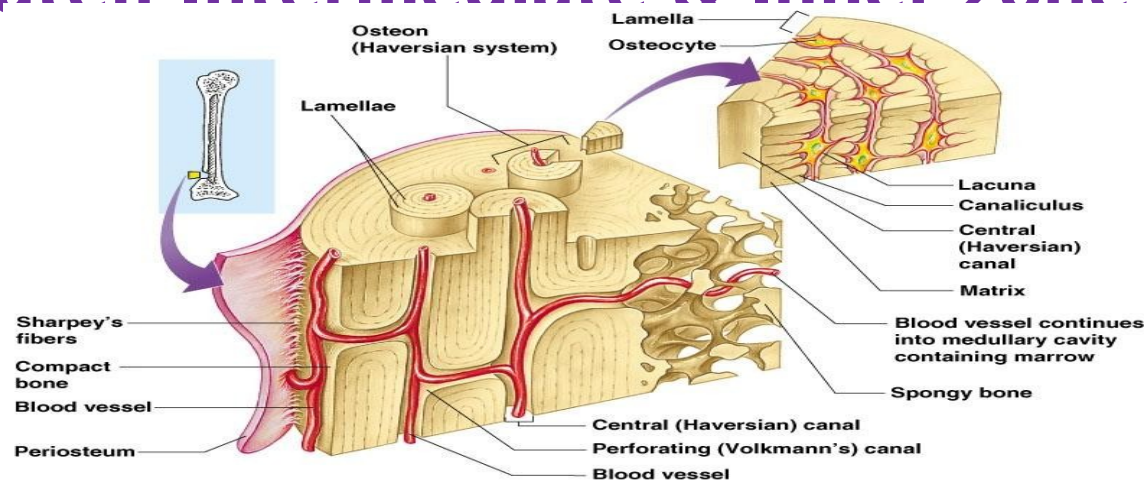
1- Compact Bone



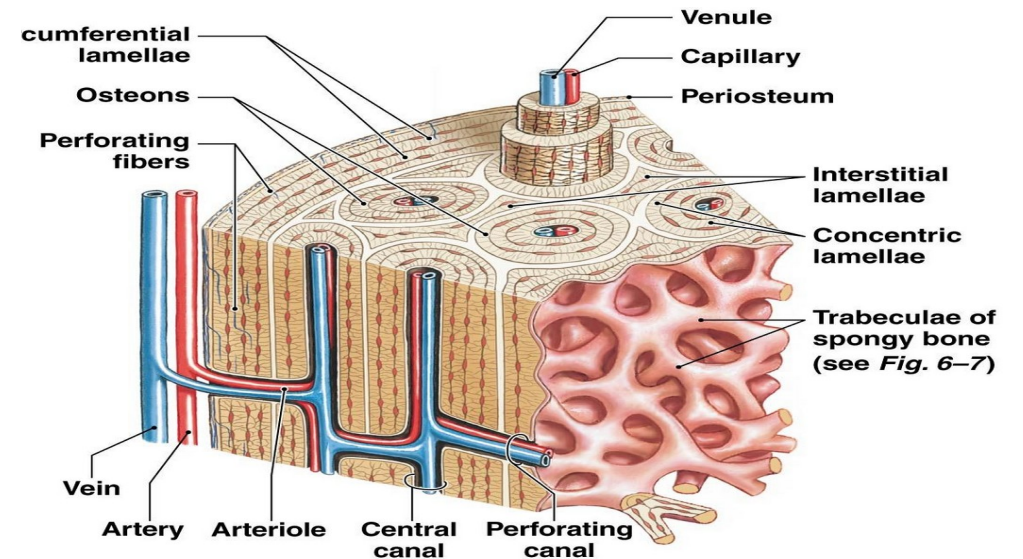
It is a solid ivory type of bone formed of regularly arranged lamellae.

Taking a section in the shaft of a long bone, 3 zones are recognized:

Outer, Intermediate & Inner zone



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a The organization of osteons and lamellae in compact bone

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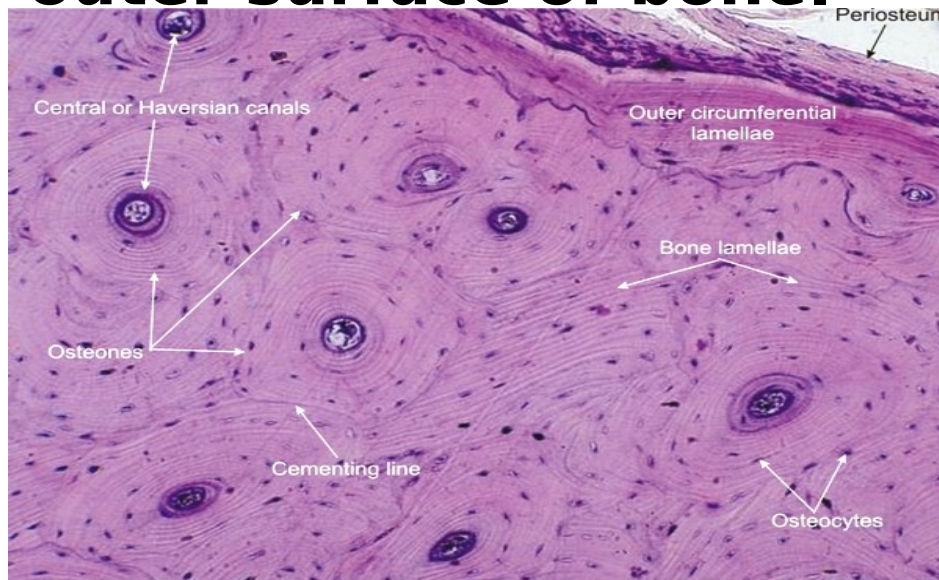


A) Outer zone: Periosteum

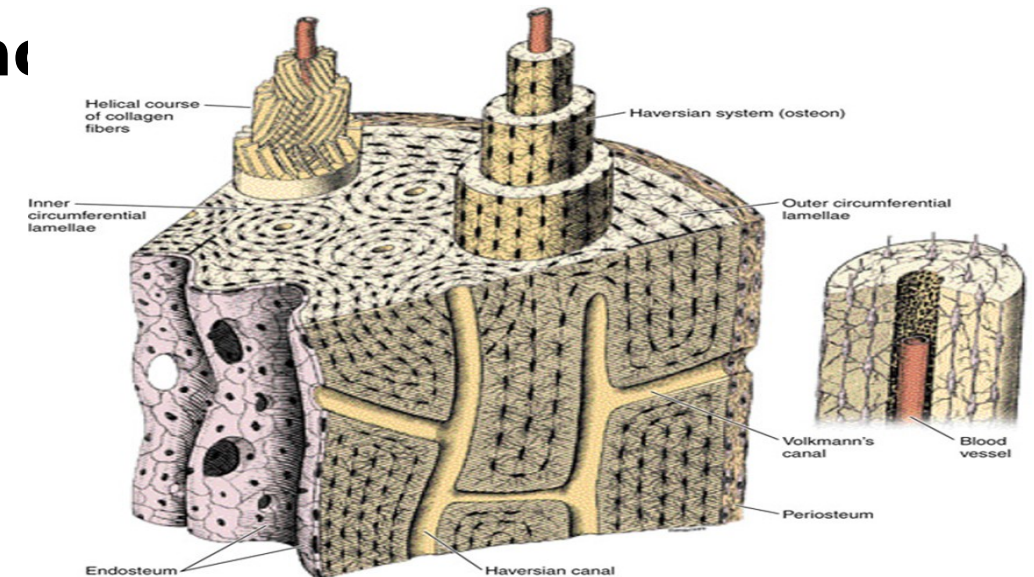
- **Outer surface is covered by a periosteum formed of 2 layers.**

Outer circumferential lamellae

- **Calcified bone lamellae regularly arranged parallel to the outer surface of bone.**



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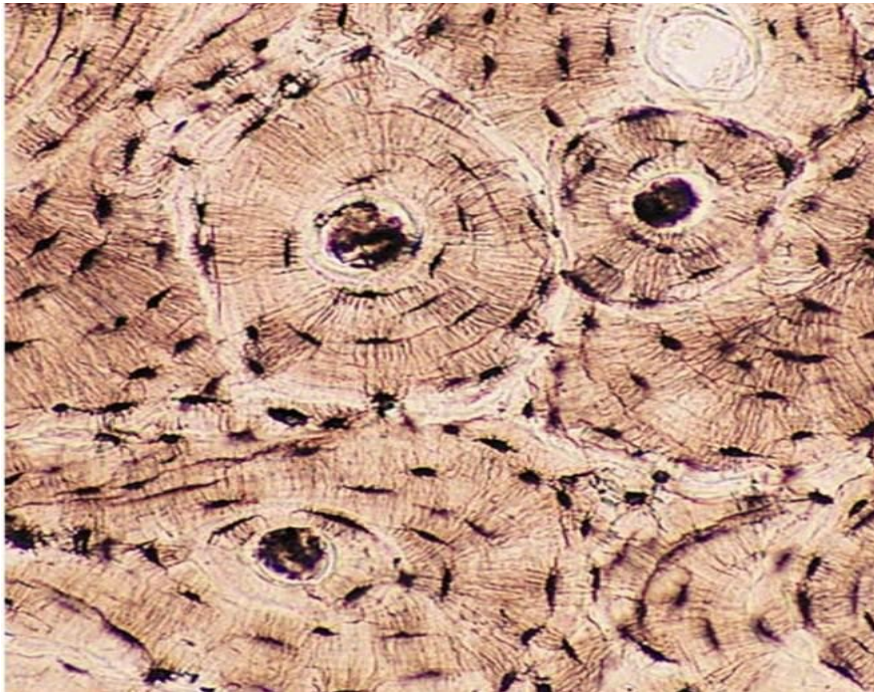
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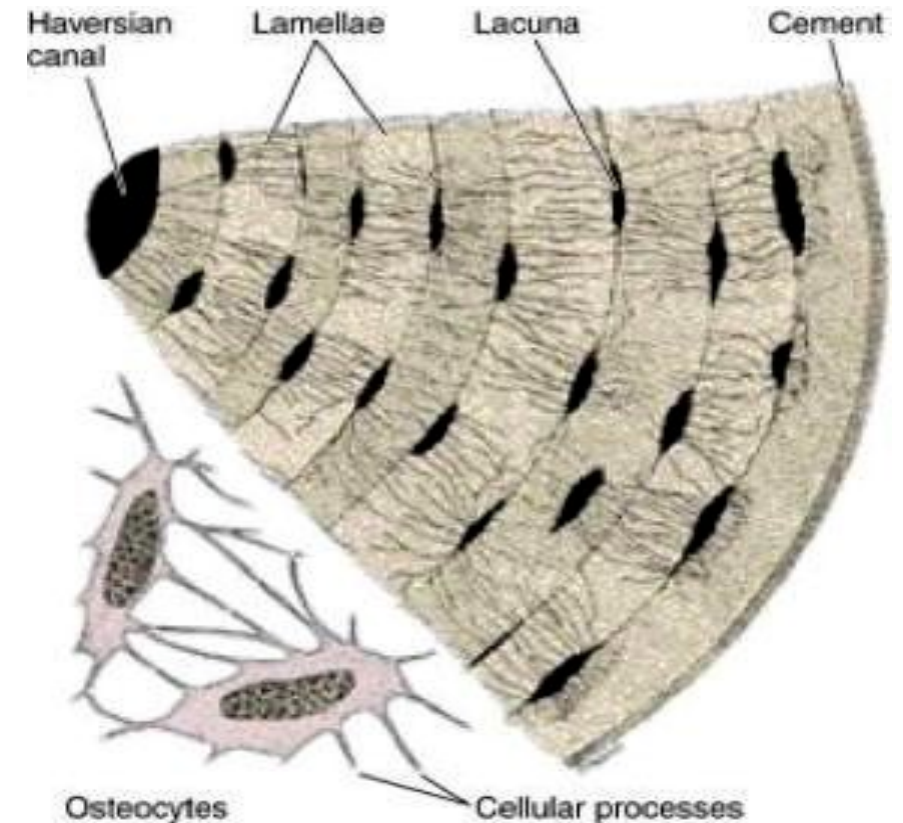
B) Intermediate Zone

1- Haversian system

2- Interstitial lamellae



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1- Haversian system (osteon)

It is the **structural unit** of compact bone

It is formed of :

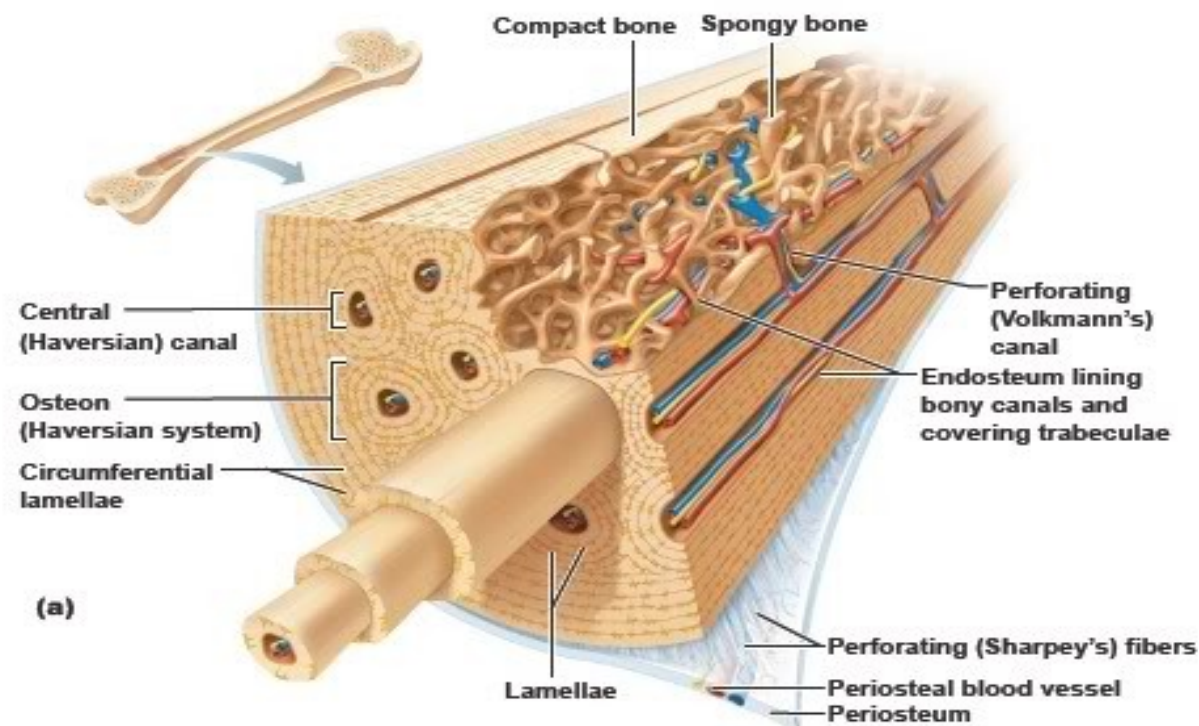
Haversian canals - bone lamellae - bone

- **Haversian system** is composed of cylinders of concentric types of bone lamellae (5-20).
 - Extend through the long axis of bone.
 - Osteocytes inside their lacunae are present in lamellae
- (Haversian system)



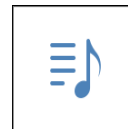
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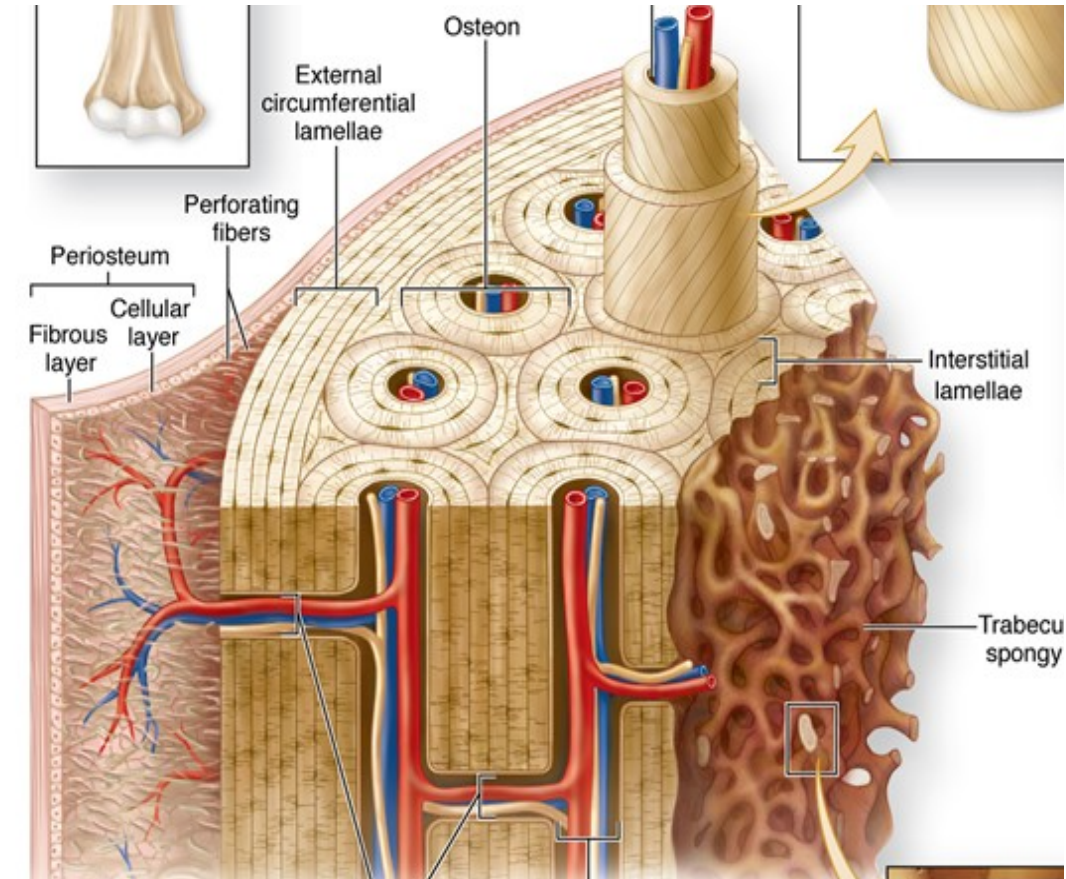
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- **Haversian canals** are interconnected by transverse or oblique canals called “**Volkman's canals**”.
- **Volkman's canals** act as connecting channels between blood vessels in the canals and those of the **periosteum and endosteum**.
- Both canals are lined by osteogenic cells, osteoblasts and osteoclasts.
- Contain loose C.T. with blood vessels and nerves.



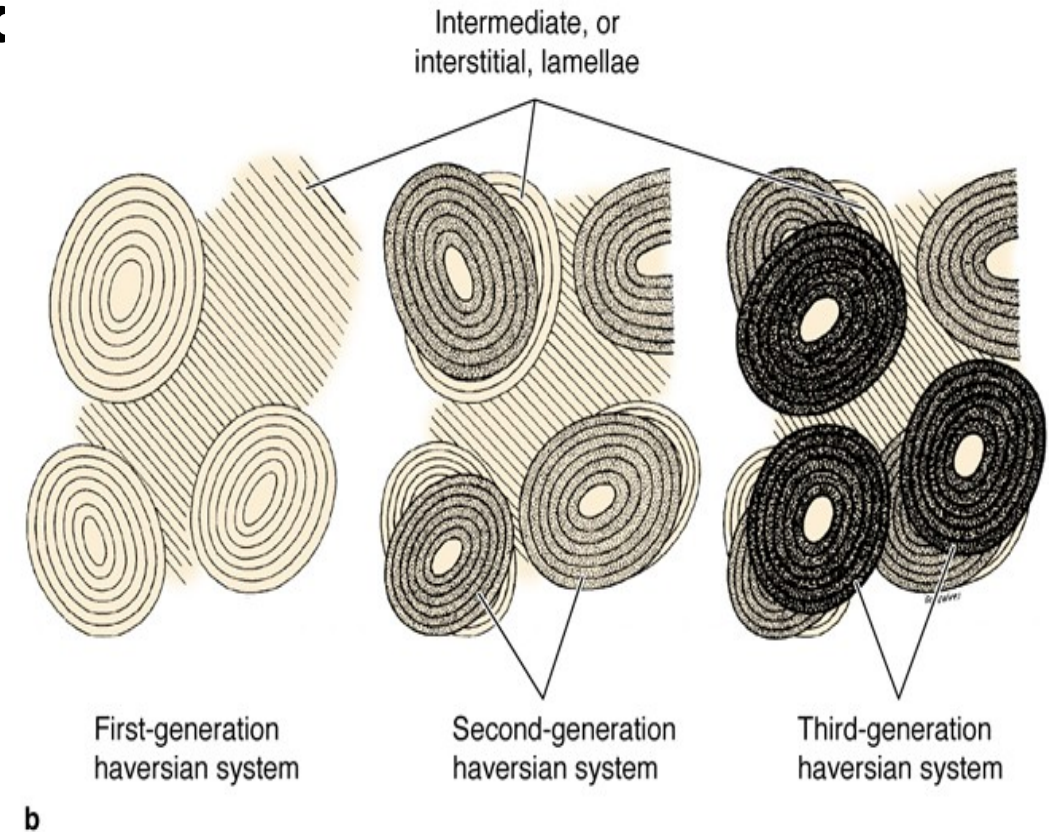
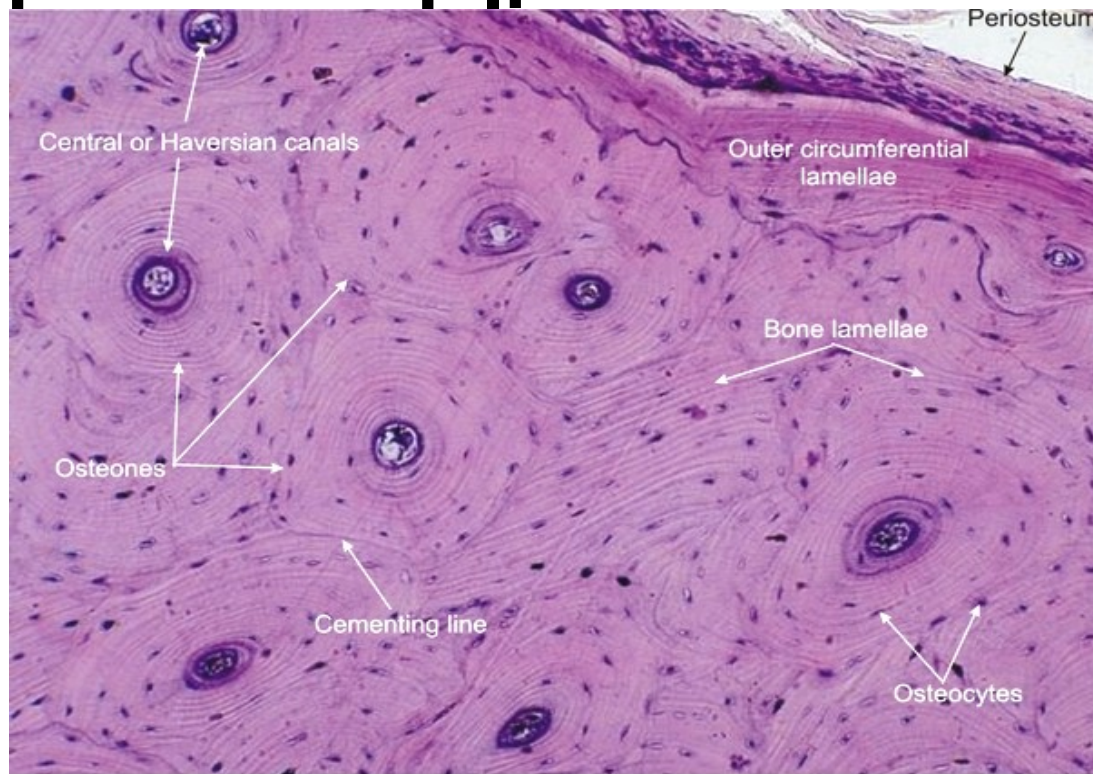
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2- Interstitial lamellae

Irregular calcified bone lamellae . They represent remnant of old Haversian system



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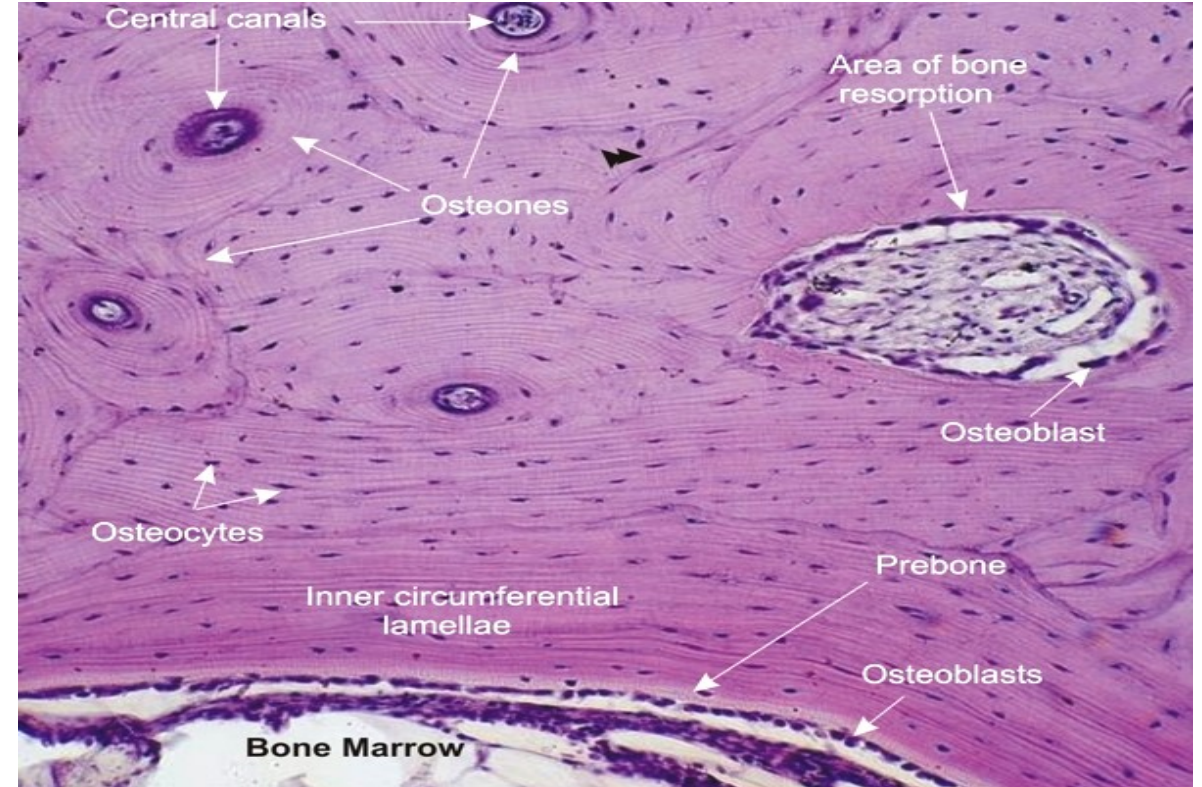
C) Inner zone

- Inner circumferential lamellae:

Lamellae of calcified bone matrix surrounding and parallel to the inner surface of bone

- Endosteum

Lining the bone marrow cavity.



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Lecture Quiz



-The outer circumferential lamellae are present:

- A. Around endosteum
- ☒ B. Under periosteum
- C. Between Haversian systems
- D. Around the Haversian canal



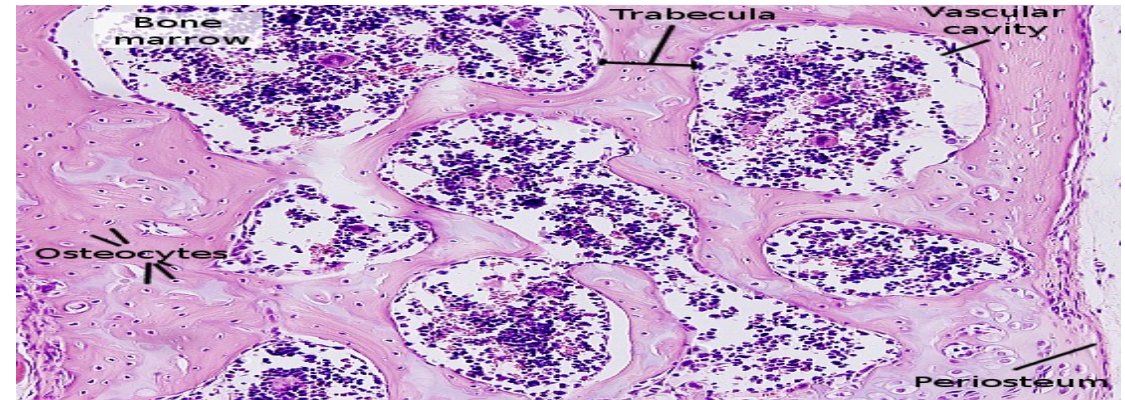
2- Cancellous Bone



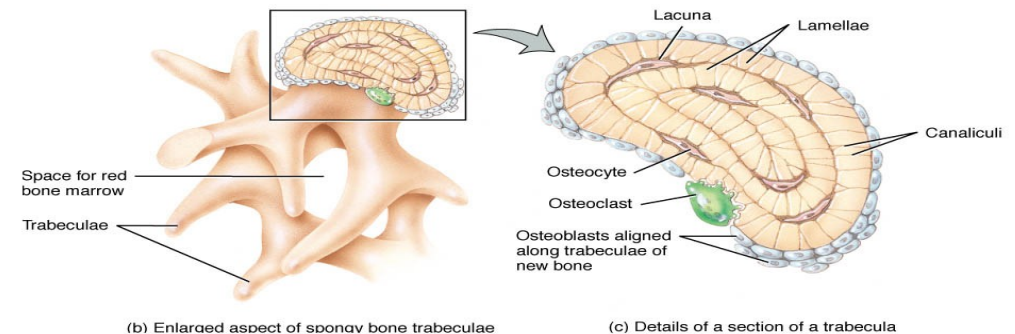
Microscopic structure:

- It is spongy in shape.
- Composed of branching and anastomosing trabeculae of bone with bone marrow spaces in between.

- Bone trabeculae are formed of irregularly arranged **bone lamellae**, **osteocytes** inside lacunae are seen in between these lamellae.

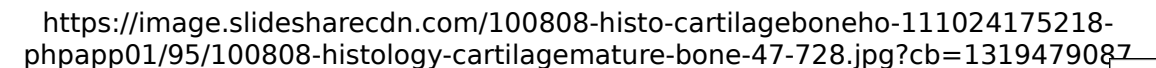
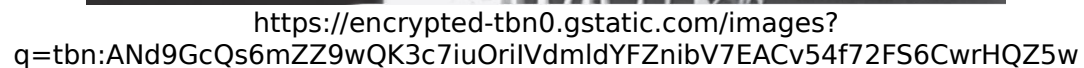


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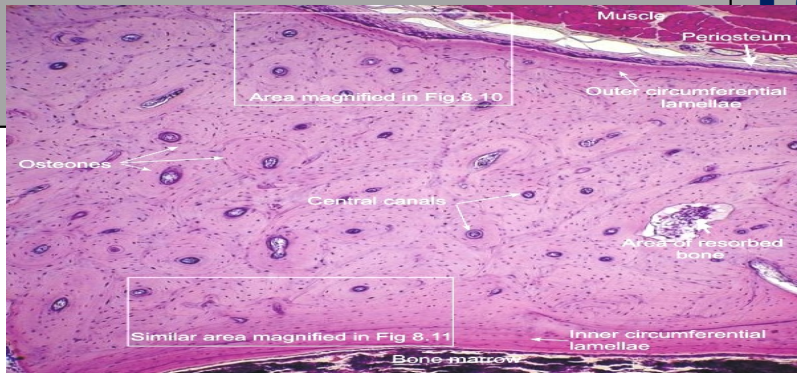


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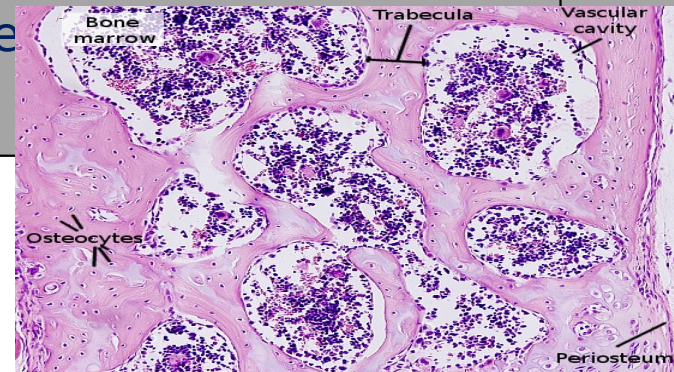




Cancellous bone	Compact bone	
Looks spongy	Looks solid	Gross appearance
1. Epiphysis of long bones. 2. Dipole of the skull bones. 3. Bodies of vertebrae ,ribs & sternum.	1. Shaft of long bones. 2. Outer & inner tables of the skull bones. 3. Outer covering of vertebrae, ribs & sternum.	Sites
▪ Bone lamellae are in the form of irregularly-arranged trabeculae which branch & anastomose ▪ Bone marrow spaces are irregular in size & shape ▪ Lack of Haversian & Volkmann canals	▪ Bone lamellae are regularly-arranged : outer & inner circumferential , concentric & interstitial lamellae ▪ Single medullay cavity containing bone marrow ▪ Contains Haversian canals	Structure



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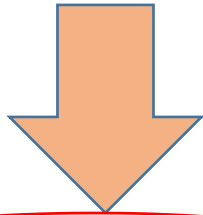


Osteogenesis/ Development of bone/ Ossification

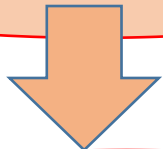


It is the process of bone formation

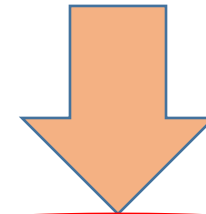
In the intrauterine life, formation of bone occurs by two ways:



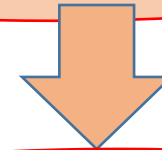
**Intramembranous
ossification**



- **Flat bones as bones of skull vault, maxilla, mandible & Clavicle**



**Endochondral or
intra-cartilagenous
ossification**



- **Long & short bones**
- **Vertebrae**





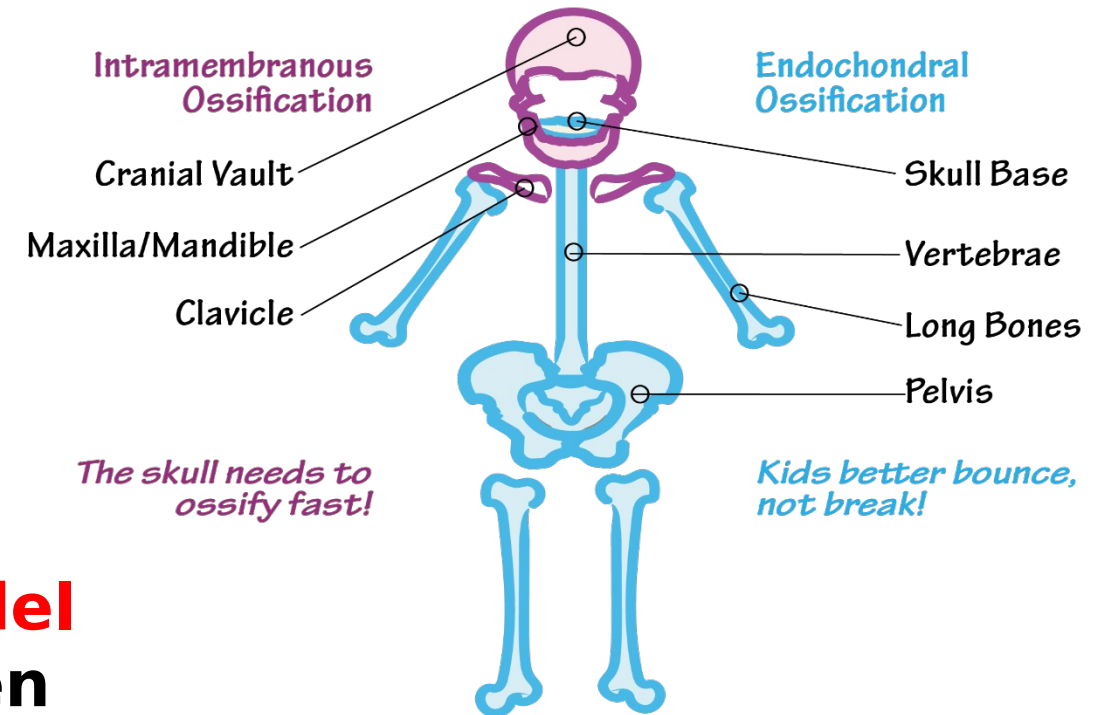
1- Intramembranous ossification :

- Bone is formed from a **mesenchymal membrane**.

2- Endochondral Ossification (Intracartilagenous)

Bone is formed as a **cartilage model** (for the future bone) which is then destroyed and replaced by the bone.

Intramembranous vs. Endochondral



<http://d1j63owfs0b5j3.cloudfront.net/term/images/538-1488452477865.png>



Bone Growth

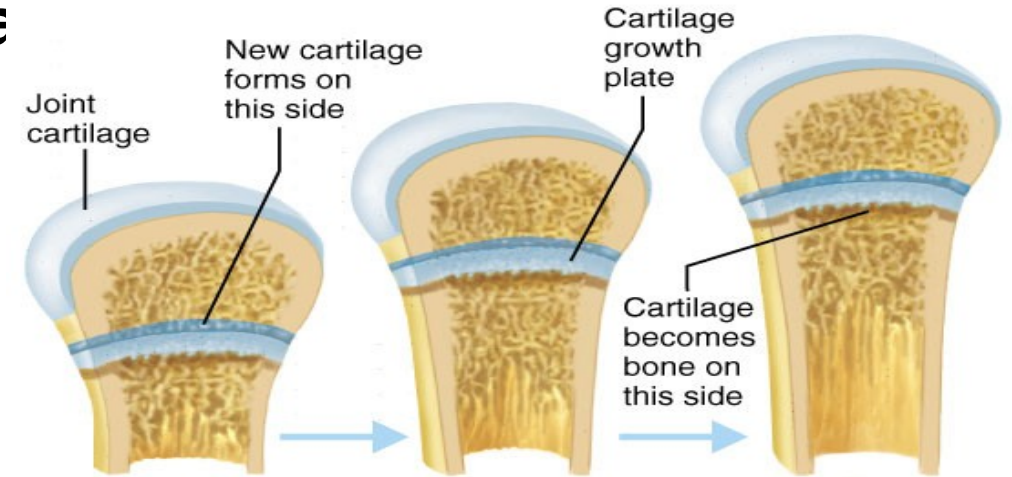


A- Growth in width (Appositional growth):

As a result of activity of **osteogenic cells**, (division and differentiation into **osteoblasts**) continued deposition of bone occurs under the periosteum and resorption of the old bone in the center of the shaft (**osteoclasts**) is preserved.

B- Growth in length (interstitial growth) :

Long bone continue to grow in length as a result of interstitial growth of the epiphyseal plate of cartilage



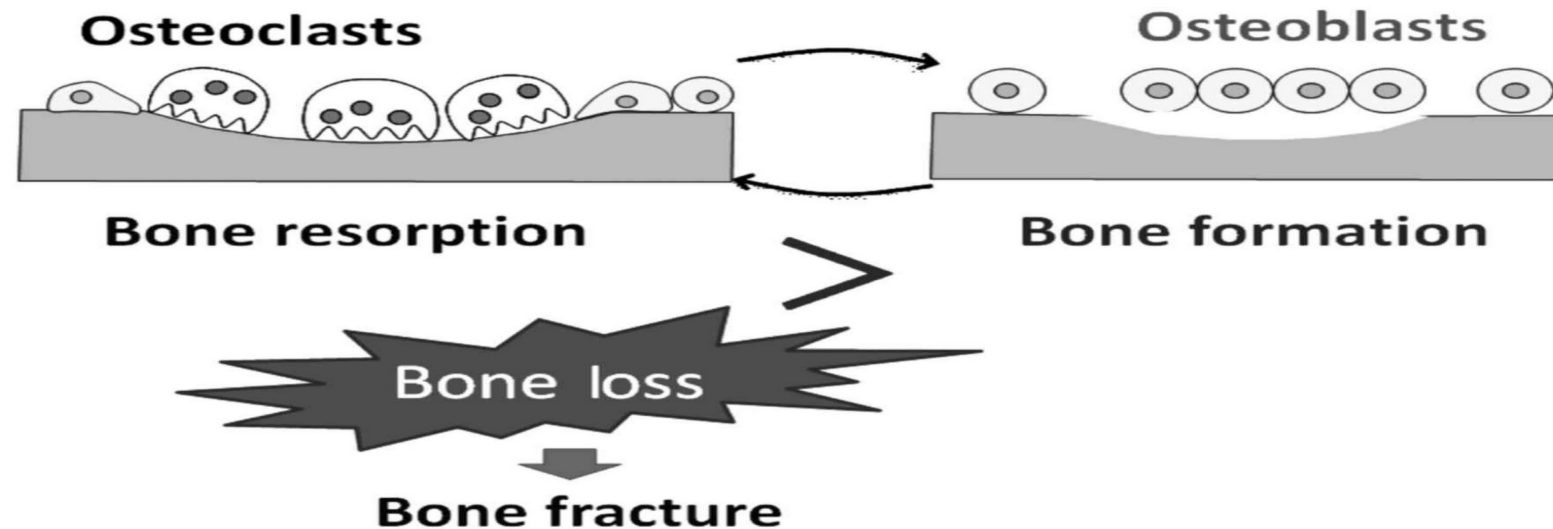
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https://www.google.com.eg/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=rja&uact=8&ved=2ahUKEwi5kuXom5HiAhVOJhoKHc_AACgQjRx6BAGBEAU&url=https%3A%2F%2Fslideplayer.com%2Fslide%2F10033363%2F&psig=AOvVaw1pLYL-tXC3Rstyo4HYY41h&ust=155758641229





Bone remodeling is a lifelong process where mature bone tissue is removed by **Osteoclast** (a process called *bone resorption*) and new bone tissue is formed by **Osteoblasts** (a process called *ossification* or *new bone formation*).



https://www.spandidos-publications.com/article_images/ijmm/39/2/IJMM-39-02-0261-g00.jpg



Medical Applications



Effect of **calcium deficiency** ($\downarrow$ Ca in diet or $\downarrow$ vit. D)

In children **Rickets**

**Defective calcification $\rightarrow$
deformed weak bone & slow
growth**



<https://www.natural-health-news.com/wp-content/uploads/2015/02/Rickets.jpg>

New Five Year Program

In adult

Osteomalacia

**Decalcification of bone $\rightarrow$ weak
bone & liable to fracture**



<http://jewishvaluesnetwork.org/wp-content/uploads/2018/11/osteomalacia-signs-and-symptoms-best-of-rickets-disease-in-adults-bing-images-of-osteomalacia-signs-and-symptoms.jpg>

Musculo-skeletal Module



Lecture Quiz



- Cancellous bone:

- A. Is formed of bone trabeculae and bone marrow spaces
- B. Its bone lamellae are regularly arranged
- C. Contains Haversian systems
- D. Bone marrow spaces are lined by osteoclasts only



Key Points



- Microscopic structure of bone matrix.
- Microscopic structure of periosteum & endosteum.
- Differentiate between immature & mature bone.
- Histological structure of compact & cancellous bone.
- Differentiate between intramembranous & intracartilaginous ossification.
- Bone growth, remodeling & medical application.

Summary



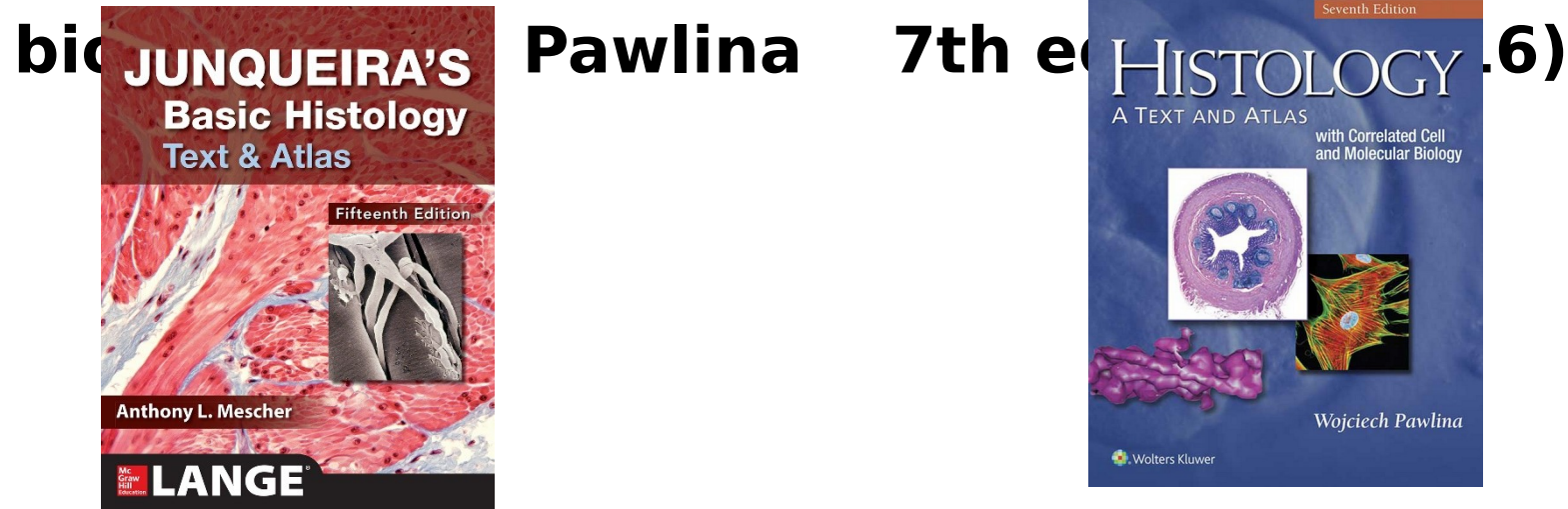
1. Periosteum is the outer membrane covering of bone
2. Endosteum is the inner membrane lining the inner surfaces of bone.
3. The calcified bone lamellae are deposited regularly in compact bone
4. The lamellae of compact bone are organized in: outer and inner circumferential lamellae, concentric lamellae and interstitial lamellae
5. The structural unit of compact bone is the Haversian system or the osteon.
6. Bone grows in width “appositional bone growth” by addition of bone matrix by the periosteum and endosteum.
7. Bone grows in length by interstitial growth of the epiphyseal plate of cartilage.



SUGGESTED TEXTBOOKS



- 1. Junqueira's Basic Histology: Text and Atlas, 15th Edition by Anthony Mescher (2018)**
- 2. Histology a text and atlas with correlated cell and molecular**



THANK
YOU

